

WHAT IS CLAIMED IS:

1. A semiconductor film formed on an insulative surface, wherein

the semiconductor film is crystalline, includes a catalyst element that is capable of promoting crystallization of a semiconductor material of the semiconductor film, and includes at least one region having a plurality of minute holes formed therein.

2. The semiconductor film according to claim 1, wherein the at least one region of the semiconductor film includes substantially no higher semiconductor compound of the catalyst element, and the catalyst element is present in a form of solid solution in the crystalline semiconductor film.

3. The semiconductor film according to claim 2, wherein the semiconductor film is substantially made of Si, the catalyst element is a metal element M, and the higher semiconductor compound has a composition of M_xSi_y ($x > y$).

4. The semiconductor film according to claim 2, wherein the at least one region of the semiconductor film includes substantially no lower semiconductor compound of the catalyst element.

5. The semiconductor film according to claim 4, wherein the semiconductor film is substantially made of Si, the catalyst element is a metal element M, and the lower semiconductor compound has a composition of M_xSi_y ($x \leq y$).

6. The semiconductor film according to claim 1, wherein a concentration of the catalyst element in the at least one region of the semiconductor film is about 1×10^{17} atoms/cm³ or less.

7. A semiconductor film formed on an insulative surface, wherein:

the semiconductor film includes an active region formed from a crystalline semiconductor layer and including a catalyst element that is capable of promoting crystallization of a semiconductor material of the semiconductor film;

the active region includes a first region, and a pair of second regions that are formed adjacent to and on opposite sides of the first region; and

the first region of the crystalline semiconductor layer includes a plurality of minute holes.

8. The semiconductor film according to claim 7, wherein the first region includes substantially no higher semiconductor compound of the catalyst element, and the catalyst element is in a form of solid solution in the crystalline semiconductor layer.

9. The semiconductor film according to claim 8, wherein the crystalline semiconductor layer is substantially made of Si, the catalyst element is a metal element M, and the higher semiconductor compound has a composition of M_xSi_y ($x > y$).

10. The semiconductor film according to claim 9, wherein the first region includes substantially no lower semiconductor compound of the catalyst element.

11. The semiconductor film according to claim 10, wherein the crystalline semiconductor layer is substantially made of Si, the catalyst element is a metal element M, and the lower semiconductor compound has a composition of M_xSi_y ($x \leq y$).

12. The semiconductor film according to claim 7, wherein a concentration of the catalyst element in the first region is about 1×10^{17} atoms/cm³ or less.

13. The semiconductor film according to claim 7, wherein a concentration of the catalyst element in the pair of second regions is higher than that in the first region.

14. The semiconductor film according to claim 13, wherein a concentration of the catalyst element in the pair of second regions is in a range of about 1×10^{18} atoms/cm³ to about 1×10^{20} atoms/cm³.

15. The semiconductor film according to claim 7, wherein the pair of second regions of the crystalline semiconductor layer include a plurality of minute holes.

16. The semiconductor film according to claim 15, wherein the pair of second regions of the crystalline semiconductor layer include substantially no higher semiconductor compound of the catalyst element, and the catalyst element is in a form of solid solution in the crystalline semiconductor layer.

17. The semiconductor film according to claim 16, wherein the crystalline semiconductor layer is substantially made of Si, the catalyst element is a metal element M, and the higher semiconductor compound has a composition of M_xSi_y ($x > y$).

18. The semiconductor film according to claim 16, wherein the pair of second regions include substantially no lower semiconductor compound of the catalyst element.

19. The semiconductor film according to claim 18, wherein the crystalline semiconductor layer is substantially made of Si, the catalyst element is a metal element M, and the lower semiconductor compound has a composition of M_xSi_y ($x \leq y$).

20. The semiconductor film according to claim 15, wherein a concentration of the catalyst element in the pair of second regions is about 1×10^{17} atoms/cm³ or less.

21. The semiconductor film according to claim 7, wherein the pair of second regions include a group VB impurity element giving n-type conductivity.

22. The semiconductor film according to claim 7, wherein the active region includes the first region, the pair of second regions, and a gettering region capable of attracting the catalyst element.

23. The semiconductor film according to claim 22, wherein a concentration of the catalyst element in the gettering region is higher than that in the first region.

24. The semiconductor film according to claim 23, wherein a concentration of the catalyst element in the gettering region is in a range of about 1×10^{18} atoms/cm³ to about 1×10^{20} atoms/cm³.

25. The semiconductor film according to claim 22, wherein a concentration of the catalyst element in the gettering region is higher than that in the first region and that in the pair of second regions.

26. The semiconductor film according to claim 22, wherein the gettering region has a larger amorphous component content than in the first region and in the pair of second regions.

27. The semiconductor film according to claim 22, wherein the gettering region includes a group VB impurity element giving n-type conductivity and a group IIIB impurity element giving p-type conductivity.

28. The semiconductor film according to claim 22, wherein the gettering region includes at least one rare gas element selected from the group consisting of Ar, Kr and Xe.

29. The semiconductor film according to claim 1, wherein the plurality of minute holes are formed as a result of removing masses of a semiconductor compound of the catalyst element.

30. The semiconductor film according to claim 1, wherein diameters of the plurality of minute holes are in a range of about 0.05 μm to about 1.0 μm .

31. The semiconductor film according to claim 1, wherein an average surface roughness Ra of the crystalline semiconductor layer is in a range of about 4 nm to about 9 nm at least in the first region.

32. The semiconductor film according to claim 1, wherein the catalyst element is at least one metal element selected from the group consisting of Ni, Co, Sn, Pb, Pd, Fe and Cu.

33. A method for manufacturing a semiconductor film, comprising the steps of:

(a) forming an amorphous semiconductor layer on an insulative surface;

(b) adding a catalyst element capable of promoting crystallization to the amorphous semiconductor layer and then performing a first heat treatment so as to crystallize the amorphous semiconductor layer, thereby obtaining a crystalline semiconductor layer;

(c) performing a first gettering process to remove the catalyst element from the semiconductor layer; and

(d) performing a second gettering process that is different from the first gettering process to remove the catalyst element from the semiconductor layer.

34. The method for manufacturing a semiconductor film according to claim 33, wherein the step (c) includes removing at least large masses of a semiconductor compound of the catalyst element present in the crystalline semiconductor layer.

35. The method for manufacturing a semiconductor film according to claim 33, wherein the step (d) includes moving at least a part of the catalyst element remaining in the crystalline semiconductor layer so as to form a low-catalyst-concentration region in the crystalline semiconductor layer, the low-catalyst-concentration region having a lower catalyst element concentration than in other regions.

36. The method for manufacturing a semiconductor film according to claim 33, wherein the step (c) includes a step of removing a higher semiconductor compound of the catalyst element, and the low-catalyst-concentration region includes substantially no higher semiconductor compound.

37. The method for manufacturing a semiconductor film according to claim 36, wherein the crystalline semiconductor layer is substantially made of Si, the catalyst element is a metal element M, and the higher semiconductor compound has a composition of M_xSi_y ($x > y$).

38. The method for manufacturing a semiconductor film according to claim 33, wherein the step (d) includes a step of moving the catalyst element forming a lower semiconductor compound of the catalyst element, and the low-catalyst-concentration region includes substantially no lower semiconductor compound.

39. The method for manufacturing a semiconductor film according to claim 38, wherein the crystalline semiconductor layer is substantially made of Si, the catalyst element is a metal element M, and the lower semiconductor compound has a composition of M_xSi_y ($x \leq y$).

40. The method for manufacturing a semiconductor film according to claim 33, wherein the step (d) includes a step of moving the catalyst element present in a form of solid solution in the crystalline semiconductor layer.

41. The method for manufacturing a semiconductor film according to claim 33, wherein the step (c) includes a step of selectively etching away a semiconductor compound of the catalyst element.

42. The method for manufacturing a semiconductor film according to claim 41, wherein the etching process in the step (c) is performed by using acid including at least hydrogen fluoride as an etchant.

43. The method for manufacturing a semiconductor film according to claim 33, wherein the step (d) includes a step of dissolving, in the crystalline semiconductor film, the catalyst element forming a semiconductor compound of the catalyst element remaining in the crystalline semiconductor film.

44. The method for manufacturing a semiconductor film according to claim 33, wherein the step (d) includes a step of forming a gettering region or a gettering layer capable of at-

tracting the catalyst element, and a step of performing the second heat treatment so that the catalyst element remaining in the crystalline semiconductor film is moved into the gettering region or the gettering layer.

45. The method for manufacturing a semiconductor film according to claim 44, wherein the gettering region or the gettering layer has a larger amorphous component content than in other regions of the crystalline semiconductor film.

46. The method for manufacturing a semiconductor film according to claim 44, wherein the gettering region or the gettering layer includes a group VB impurity element giving n-type conductivity.

47. The method for manufacturing a semiconductor film according to claim 46, wherein the impurity element includes at least one element selected from the group consisting of P, As and Sb.

48. The method for manufacturing a semiconductor film according to claim 44, wherein the gettering region or the gettering layer includes a group IIIB impurity element giving p-type conductivity.

49. The method for manufacturing a semiconductor film according to claim 48, wherein the impurity element includes at least one of B and Al.

50. The method for manufacturing a semiconductor film according to claim 44, wherein the gettering region or the gettering layer includes at least one rare gas element selected from the group consisting of Ar, Kr and Xe.

51. The method for manufacturing a semiconductor film according to claim 44, wherein at least one of the impurity element and the at least one rare gas element included in the gettering region or the gettering layer are introduced by an ion implantation method.

52. The method for manufacturing a semiconductor film according to claim 44, further comprising a step of removing the gettering region or the gettering layer after the step (d).

53. The method for manufacturing a semiconductor film according to claim 33, wherein the step (b) includes a step of selectively adding the catalyst element to a region of the amorphous semiconductor film and then performing the first heat treatment so that a crystal growth process proceeds laterally

from the region to which the catalyst element has been selectively added.

54. The method for manufacturing a semiconductor film according to claim 33, wherein the step (b) includes a step of irradiating the crystalline semiconductor film with laser light after the first heat treatment.

55. The method for manufacturing a semiconductor film according to claim 54, wherein:

the step (c) includes a step of selectively etching away a semiconductor compound of the catalyst element; and

the etching step is performed after the first heat treatment step and before the laser light irradiation step in the step (b), and serves also as a surface cleaning step.

56. The method for manufacturing a semiconductor film according to claim 33, wherein:

the step (b) includes a step of forming an insulating film on the crystalline semiconductor film after the first heat treatment step;

the step (c) includes a step of selectively etching away a semiconductor compound of the catalyst element; and

the etching step is performed after the first heat treatment step and before the insulating film formation step in the step (b), and serves also as a surface cleaning step.

57. The method for manufacturing a semiconductor film according to claim 33, wherein the catalyst element is at least one metal element selected from the group consisting of Ni, Co, Sn, Pb, Pd, Fe and Cu.

58. A method for manufacturing a semiconductor device, comprising the steps of:

providing a semiconductor film manufactured by the method for manufacturing a semiconductor film according to claim 33; and

producing a thin film transistor including the semiconductor film in an active region thereof.

59. The method for manufacturing a semiconductor device according to claim 58, wherein:

the active region includes a channel region, a source region and a drain region; and

the step of producing the thin film transistor includes a step of forming at least the channel region in the low-catalyst-concentration region.

60. The method for manufacturing a semiconductor device according to claim 59, wherein the step of producing the thin film transistor includes a step of forming the channel region, the source region and the drain region in the low-catalyst-concentration region.

61. A semiconductor device, comprising a thin film transistor including the semiconductor film according to claim 1 in an active region thereof.

62. The semiconductor device according to claim 61, wherein the active region includes a channel region, a source region and a drain region, and at least the channel region is formed in the first region.

63. The semiconductor device according to claim 62, wherein the channel region, a junction region between the channel region and the source region, and a junction region between the channel region and the drain region are formed in the first region.

64. The semiconductor device according to claim 63, wherein the junction region between the channel region and the source region, and the junction region between the channel re-

gion and the drain region are each extending within about 2 μm from a junction boundary thereof.

65. The semiconductor device according to claim 61, wherein the active region includes a channel region, a source region and a drain region, the channel region is formed in the first region, and the source region and the drain region are formed in the pair of second regions.

66. The semiconductor device according to claim 61, wherein:

the semiconductor device further comprises a gate insulating film formed on the semiconductor film over the channel region, and a gate electrode formed so as to oppose the channel region via the gate insulating film; and

the gate electrode is formed from a metal film including at least one element selected from the group consisting of W, Ta, Ti and Mo.

67. An electronic device, comprising the semiconductor device according to claim 61.

68. The electronic device according to claim 67, further comprising a display section including a plurality of pixels,

wherein a display signal is supplied to each of the plurality of pixels via the semiconductor device.